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Clinton, New Jersey, Radon Mitigation Follow-Up and Long-Term Monitoring

PEI Associates, Inc., Cincinnati, OH

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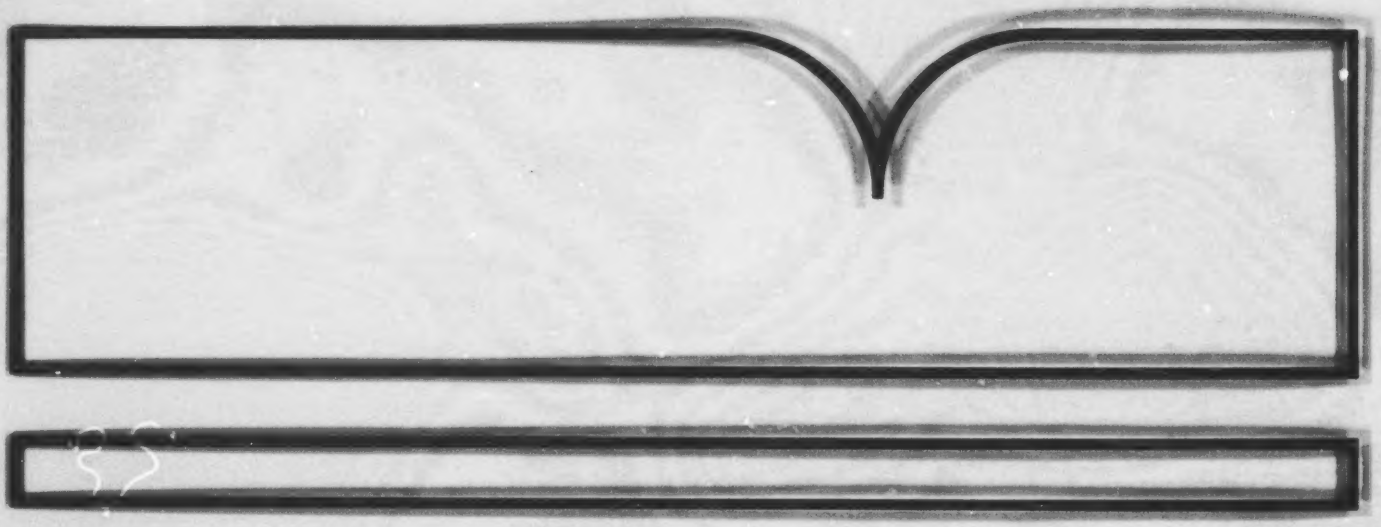

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CLINTON, NEW JERSEY, RADON MITIGATION FOLLOW-UP AND LONG-TERM MONITORING

by

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ABSTRACT

During 1986, the United States Environmental Protection Agency demonstrated radon reduction techniques in 10 houses in Clinton, New Jersey. Initial radon levels in the 10 houses ranged from 400 to 2200 pCi/liter. Radon reductions of more than 95 percent were achieved by using a variety of sub-slab ventilation techniques.

Since January 1987, the radon levels in the 10 houses have been monitored with alpha track detectors. The detectors have been installed and removed on a quarterly basis. Three detectors were employed on the lowest level of each house, and three detectors were employed on the next higher level. Results of the comparison between the radon concentration measured during the first and second quarters of 1987 showed that most of the houses had slightly higher concentrations during the second quarter. These results are contrary to expected trends.

Two houses with slightly elevated radon levels received additional radon reduction applications at the end of the second quarter of 1987. In one of the houses, the radon concentration was successfully reduced; in the other house, radon concentrations were essentially unchanged.

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SECTION 1

INTRODUCTION

Data are being collected on the radon levels in 10 houses in Clinton, New Jersey. The U.S. Environmental Protection Agency (EPA), Air And Energy Research Laboratory (AAERL), had previously screened these 10 houses for indoor radon and had retrofitted them with mitigation systems. The monitoring phase of their activity occurred in the spring of 1986; mitigation systems were installed in the fall of 1986, in time for the winter heating season. All work in 1986 was performed by Research Triangle Institute (RTI) and is documented in a report entitled "Development and Demonstration of Indoor Radon Reduction Measures for 10 Homes in Clinton, New Jersey," July 1987 (Reference 1).

For the purpose of compiling a complete data base showing the effects of the radon reduction systems installed in Clinton in 1986, AAERL has contracted with PEI Associates, Inc., to perform the followup radon monitoring. Alpha track detectors (ATDs) were installed in each house in January 1987 and retrieved in April 1987. A second set of ATDs was installed in April 1987 and retrieved in July 1987. A special study entailed installation of charcoal canisters in two of the houses in June and July 1987.

This report presents the results obtained on radon concentrations in each of the 10 homes during the April-June sampling period and compares these

results with those obtained during the January-March sampling period. It also includes a discussion of additional mitigation performed during a special study at two of the houses, the monitoring techniques incorporated, and planned future work.

SECTION 2

POSTMITIGATION TASKS IN STUDY HOUSES

FIRST SAMPLING PERIOD

A complete description of the systems installed in each study house is presented in "Development and Demonstration of Indoor Radon Reduction Measures for 10 Homes in Clinton, New Jersey" (Reference 1). During the first period of followup activities, a problem arose concerning the heating system in one of the split-level houses. Several options were studied to correct this problem. The corrective action implemented consisted of replacing the furnace blower motor with one of larger horsepower and reconstructing the duct plenum at the point where the existing duct system connected with the attic duct system. These corrective actions brought the total cost for this radon reduction system to $4300. Although this same system was planned for installation in a second house of the same construction, project funds were insufficient for the proposed action. The same radon reduction system was installed in the second house as in the first house, and the additional expense to correct the heating problem in the second house will be similar to that in the first [approximately $1000 (1987 dollars)].

SECOND SAMPLING PERIOD

During the week of June 29 through July 3, 1987, special studies were performed at two of the study houses to determine if additional remediation could be achieved. The two houses subjected to this special study were C7-E

and C10-D. The results obtained during the first sampling period had shown both houses still had elevated radon concentrations with respect to the target concentration of 4 picocuries per liter (pCi/liter). The first sampling period produced 3-month average results of 10.8 and 9.1 pCi/liter on the upper and lower levels of house C7-E, respectively; and 4.8 and 10.8 pCi/liter on the upper level and basement of house C10-D, respectively. The goal of the special studies was to reduce radon levels in both houses to below the target concentration.

House C7-E

Most of the time during the special study period was spent on house C7-E, which was of a different type construction from that of all the other houses in the Clinton radon study. Grab samples were collected at numerous locations within the crawl space and the exterior walls of the house by the use of Lucas cells. A Pylon monitor operated in the continuous rate mode was also used on the outside of the house to investigate the possibility of reentrainment from the suction exhaust point. All sample results, which were assessed on a qualitative basis, indicated that two exterior block walls of the slab on grade had high radon levels, and that these walls were not affected by the block wall suction system previously installed in the house. Reentrainment had not been observed. The additional remediation warranted by these results was to apply a suction to these two walls to contain high radon concentrations.

Suction was applied to the two exterior block walls by first increasing the fan size in the suction system and then installing a 4-inch (10-cm) PVC pipe to the corner of the two adjoining walls. This 4-inch (10-cm) pipe was then joined to the existing block wall suction system. Because of access

limitations, the new pipe was run on the outside of the house. Pressure differential measurements performed at the completion of the installation indicated that the two block walls in question were adequately connected to the suction system. The cost to install this additional remediation system was approximately $500, including skilled labor and supplies.

House C10-D

Work in house C10-D was concentrated in the basement, where the previously installed system consisted of two subslab suction points--one at the sump and the other at the opposite end of the basement. Investigations of possible remedies consisted of measuring the negative pressure field below the slab, measuring the negative pressure in the block walls, and using Lucas cells to collect grab samples for qualitative analysis. These investigations revealed that the negative pressure field below the basement slab was adequately distributed throughout the entire area and that the negative pressure extended into some of the block walls. Three of the walls, those closest to the slab-on-grade portion of the house, however, showed no indication of negative pressure. Based on the investigations conducted, the additional necessary remediation consisted of sealing the area around the sump and most of the seam between the floor and walls of the basement. In addition, the three block walls determined to be without negative pressure were connected directly to the suction system by tapping into the intersecting corner of two of the walls and installing a 4-inch (10-cm) PVC pipe between the corner and the subslab suction system. Measurements were made to determine what was required to deliver adequate suction to all portions of the subslab area and basement block walls. The cost to perform the additional remediation was minimal (based on the use of a two tubes of sealant), and it is not considered an increase in the original cost of remediation.

SECTION 3

RADON MONITORING TECHNIQUES

Two monitoring techniques were used to make quantitative measurements of indoor radon concentrations during the first and second sampling periods--alpha track detectors and charcoal canisters. The measurements were made in accordance with the guidelines provided in EPA's report entitled "Interim Indoor Radon and Radon Decay Product Measurement Protocols," EPA-520/1-86-04 (Reference 2). Each technique is described here.

ALPHA TRACK DETECTORS

Alpha track detectors were obtained from Terradex Corporation in Glenwood, Illinois. The detectors use radiation-sensitive plastic to record the energy transferred by alpha particles emitted during radon decay. Each detector is self-contained in a small lattice-topped plastic casing and is provided with a paper filter to prevent entry of particles formed during radon decay. Radon, a gas, passes through the paper filter and releases an alpha particle as is decays. The alpha particles released while inside the detector transfer their energy to the plastic as they strike it and produce an energy track etching. The tracks are later counted and the number of counts are converted to a radon concentration. The exposure period of the detector is taken into account during this count.

The ATDs were deployed in each house to obtain a long-term average radon concentration. The planned exposure period was three months. Sixty-six

type SF detectors, numbered consecutively from 474801 to 474850, 477611 to 477613, and 477638 to 477650, were obtained from the supplier for subsequent deployment on April 16 and 17, 1987, and analysis at the 1 pCi/liter sensitivity level. The detectors were received in sealed aluminum packages.

A coding system was established by AEERL for use in the followup monitoring of the ten study houses in Clinton. The system provided a number between 1 and 10, followed by a letter to denote the construction type of the house. This system was used to record the placement of detectors. Because the system differed from the coding system used during the original screening work performed in Clinton, a cross-reference list was prepared between this system and the original one. Table 1 presents the cross-reference list to compare the two systems.

TABLE 1. HOUSE CODES USED IN CLINTON, NEW JERSEY STUDY HOUSES

Follow-up monitoring	1986 Screening study
C1-A	C30A
C2-B	C31B
C3-C	C33C
C4-A	C39A
C5-A	C46A
C6-B	C48B
C7-E	C24E
C8-A	C8A
C9-B	C10B
C10-D	C32D

Six ATDs were deployed in each study house. Triplicate detectors were placed in two different locations representing high-use areas of each house. The detectors were either placed on a shelf or tacked to a wall or ceiling beam. An effort was made to place the detectors at a height near the breathing zone of a child, and all detectors were placed in areas away from

exterior walls and windows. The detector number was recorded as each ATD was deployed. The detectors were deployed at random, without regard for maintaining a consecutive number sequence in each house. This was done to minimize the bias during analysis and reporting of results. To assist in recordkeeping and retrieval, the aluminum packages for each house were clipped together in separate groups. This allowed the field installer to recheck the accuracy of recorded information in the office.

The detectors were retrieved on July 20 and 23, 1987. Upon retrieval, each detector was placed into its original aluminum package, sealed closed with tape, and sent to the supplier for analysis. The six extra detectors were also returned to the supplier as blanks after the packages had been opened and labeled as if they had been deployed with the others. Table 2 presents information on the deployment of the ATDs.

CHARCOAL CANISTERS

Charcoal canisters were obtained from the EPA Office of Radiation Program's (ORP) Eastern Environmental Radiation Facility in Montgomery, Alabama. These canisters are filled with a measured amount of activated carbon and fitted with a screen to prevent spilling. Each canister is self-contained in a steel container with a filter to prevent entry of particles formed in the monitoring environment. The radon passes through the filter and adsorbs on the carbon. As the radon decays, the decay products remain on the carbon. Because the decay products are gamma emitters, the amount of radon that had decayed on the carbon can be calculated by measuring the activity of the decay products on the carbon.

The CCs are deployed in a house by removing the tape seal and placing the canister in the monitoring area. The exposure period for CCs is two to

TABLE 2. ALPHA TRACK DETECTORS DEPLOYED IN CLINTON, NEW JERSEY, DURING TESTING PERIOD 2 (APRIL-JULY 1987)

House code	Detector No.	Date installed	Date retrieved	Location
C1-A (C30A)	474804	4/16/87	7/23/87	Basement
	477644			
	477643			
	477649			First floor dinette
	477650			
	477648			
C2-B (C31B)	474838	4/16/87	7/20/87	Basement study
	474828			
	474837			
	477611			Dining room
	474843			
	474836			
C3-C (C33C)	474827	4/16/87	7/20/87	Dining room
	474840			
	474842			
	474826			Master bedroom (second floor)
	474841			
	474839			
C4-A (C39A)	477613	4/16/87	7/20/87	Family room (1st floor)
	477647			
	474815			
	474821			Basement
	474822			
	474807			
C5-A (C46A)	474848	4/17/87	7/20/87	Dining room
	477641			
	474850			
	474833			Basement
	474849			
	474834			
C6-B (C48B)	474844	4/16/87	7/20/87	Lower level, family room
	474845			
	474831			
	474829			Dining room
	477639			
	477830			

(continued)

TABLE 2 (continued)

House code	Detector No.	Date installed	Date retrieved	Location
C7-E	477642	4/16/87	7/20/87	Living room
(C24E)	477646			
	477645			
	477612			Lower level,
	474801			bedroom
	474802			
C8-A	474835	4/17/87	7/20/87	Basement bedroom
(C8A)	474806			
	474809			
	477638			Kitchen/dinette
	474847			
	474832			
C9-B	474813	4/16/87	7/20/87	Dining room
(C10B)	474814			
	474823			
	474812			Family room
	474808			(lower level)
	474811			
C10-D	474825	4/16/87	7/20/87	Kitchen counter
(C32D)	474824			
	477640			
	474810			Basement
	474820			
	474805			

three days. Two CCs were deployed in each of the houses included in the special study phase of the test. These samples were taken at the completion of the additional remediation to estimate the benefit of the additional measures.

SECTION 4

RESULTS AND DISCUSSION

The two laboratories from which the detectors were obtained reported the radon concentration results in terms of pCi/liter. Table 3 presents the concentrations reported by the analytical laboratories for the Period 2 testing. Full reports are provided in Appendix A.

Based on the control samples and the triplicate ATDs, the results reported by the analytical laboratory met the quality control objectives of the study. Table 4 presents the ATD average concentration for both sampling periods for each house and compares these levels with the premitigation levels measured by charcoal canisters. These data are also shown graphically in Figure 1. (Details of the premitigation levels can be found in Reference 1.) Results of the comparison between periods generally show radon levels similar to those measured during the first sampling period, but results for most of the houses indicate slightly higher concentrations during the second period. This comparison is contrary to expected trends, in that the first period, samples were collected during the heating season, when radon concentrations are assumed to be higher than in other seasons. As shown by the 90 percent confidence intervals around the mean values for each house between periods, the results for the second sampling period in house C2-B are significantly higher than those in the first period. The second-period results at house 5 are also significantly higher than the first-period results. All

TABLE 3. REPORTED RADON CONCENTRATIONS IN CLINTON, NEW JERSEY

House code	Alpha track detectors		Location	Charcoal Canisters (Installed after additional radon mitigation)	
	Number	Conc., pCi/liter		Number	Conc., pCi/liter
C1-A	474804	2.8	Basement		
(C30A)	477644	4.1			
	477643	4.1			
	477649	4.3	First floor		
	477650	3.7	dinette		
	477648	3.5			
C2-B	474838	15.1	Basement		
(C31B)	474828	15.1	study		
	474837	16.5			
	477611	11.2	Dining room		
	474843	12.6			
	474836	10.9			
C3-C	474827	5.4	Dining room		
(C33C)	474840	4.7			
	474842	4.3			
	474826	4.4	Master bedroom		
	474841	7.8	(2nd floor)		
	474839	4.3			
C4-A	477613	2.7	Family room		
(C39A)	477647	3.3	(1st floor)		
	474815	2.6			
	474821	2.7	Basement		
	474822	3.6			
	474807	2.9			
C5-A	474848	8.4	Dining room		
(C46A)	477641	10.4			
	474850	7.0			
	474833	15.0	Basement		
	474849	8.2			
	474834	11.6			
C6-B	474844	10.6	Lower level,		
(C48B)	474845	9.8	family room		
	474831	7.9			
	474829	10.9	Dining room		
	477639	8.1			
	477830	8.6			

(continued)

TABLE 3 (continued)

House code	Alpha track detectors		Location	Charcoal Canisters (Installed after additional radon mitigation)	
	Number	Conc., pCi/liter		Number	Conc., pCi/liter
C7-E	477642	11.2	Living room	32578	12.1 (DR)
(C24E)	477646	13.1		32541	10.9 (upper BR)
	477645	11.7			
	477612	20.2	Lower level	32588	12.4
	474801	7.8	bedroom		
	474802	8.9			
C8-A	474835	2.4	Basement,		
(C8A)	474806	1.1	bedroom		
	474809	2.0			
	477638	1.8	Kitchen/dinette		
	474847	2.8			
	474832	1.6			
C9-B	474813	3.8	Dining room		
(C10B)	474814	2.5			
	474823	2.9			
	474812	3.5	Lower level,		
	474808	5.0	family room		
	474811	2.9			
C10-D	474825	2.6	Kitchen counter	32629	4.4
(C32D)	474824	3.0			
	477640	4.4			
	474810	14.6	Basement	32579	0.5
	474820	12.0			
	474805	11.7			
Blank	474803	0.0			
Blank	474816	0.3			
Blank	474817	0.1			
Blank	474818	0.5			
Blank	474819	0.0			
Blank	474846	0.0			

TABLE 4. COMPARISON OF RADON LEVELS BETWEEN SAMPLING PERIODS

House code	ATD average Period 1, (Jan-Apr 1987) pCi/liter	ATD average Period 2, (Apr-Jul 1987) pCi/liter	Concentration at beginning of study (March 1986)
C1-A	2.6	3.7	
(C30A)	2.9	3.8	2254
C2-B	5.0	15.6	
(C31B)	3.3	11.6	691
C3-C	5.4	4.8	
(C33C)	4.2	5.5	1190
C4-A	3.4	2.9	
(C39A)	3.6	3.1	1500
C5-A	5.4	8.6	
(C46A)	8.5	11.6	635
C6-B	7.2	9.4	
(C48B)	8.4	9.2	936
C7-E	10.8	12.0	
(C24E)	9.1	12.3	426
C8-A	1.5	1.8	
(C8A)	1.7	2.1	791
C9-B	6.3	3.1	
(C10B)	6.0	3.8	670
C10-D	4.8	3.3	
(C32D)	10.8	12.8	1357

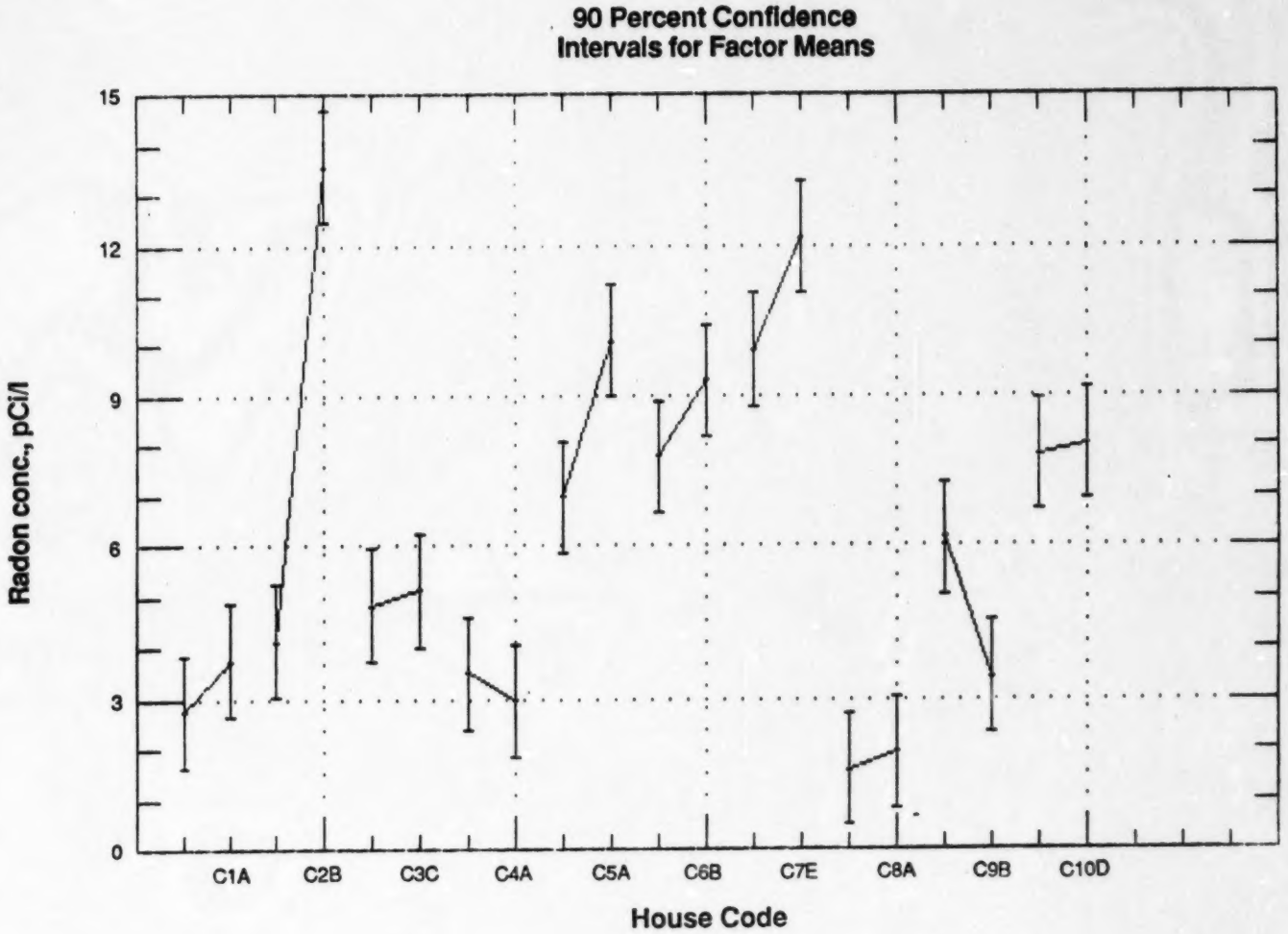

Figure 1. Comparison of Radon Concentrations in each house between sampling periods, pCi/liter.

other second-period results, although slightly different, are not significantly different from the results obtained during the first sampling period.

The overall average radon concentration for each house (1 through 10) for the 6-month period (January - July 1987) is shown in Figure 2 along with the 90 percent confidence interval around the mean. As seen in Figure 2, only three of the houses clearly display average concentrations below the target level. Figure 3 displays similar information by construction type and indicates that construction types A and C produced the lowest post-remediation concentration. Tables 5 and 6 present the mean values for various data sorts over both sampling periods.

The data presented in Table 4 and Figures 1, 2, and 3 reveal a condition that warrants further attention. Table 4 shows a second period radon concentration of over 11 pCi/liter on both levels of house C2-B. Figure 1 shows this to be significantly different than the concentration measured during period 1, yet Figure 3 shows that B type construction should have a lower concentration. These summaries and displays lead to the conclusion that the radon reduction system in house C2-B experienced reduced effectiveness during period 2.

Additional data plots are presented in Figure 4 through 6. Several interpretations can be derived from these plots of sorted data. Figure 4 shows that with the exception of type B, the values obtained during the two sampling periods are not significantly different for the various types of construction. Figure 5 shows the radon concentration to be similar between levels of the houses, with the exception of construction type D. Figure 6 shows, however, in general the first (lower) level of a house tends to have higher concentrations than the second level.

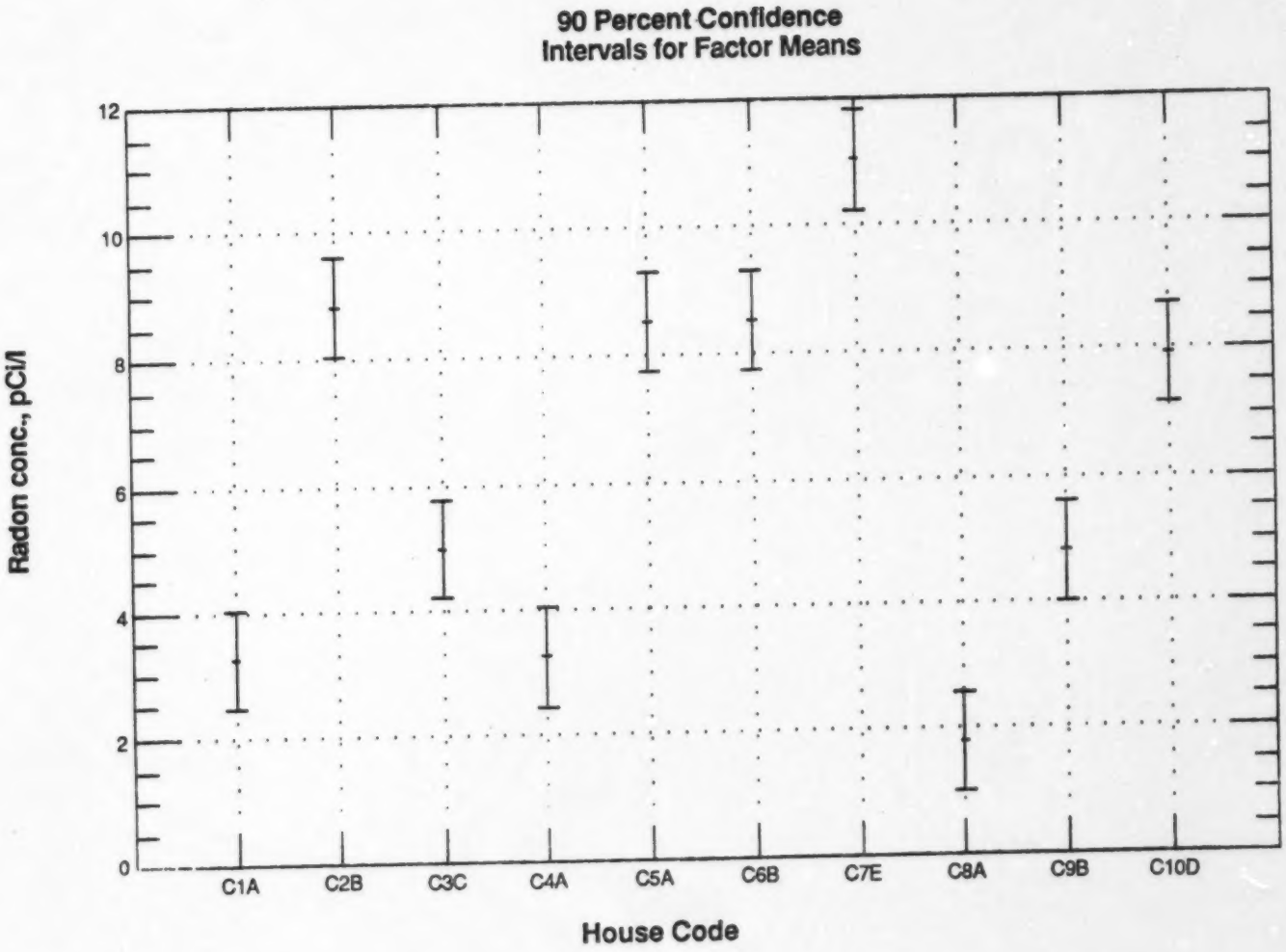

Figure 2. Six-month average radon concentration in each study house, pCi/liter.

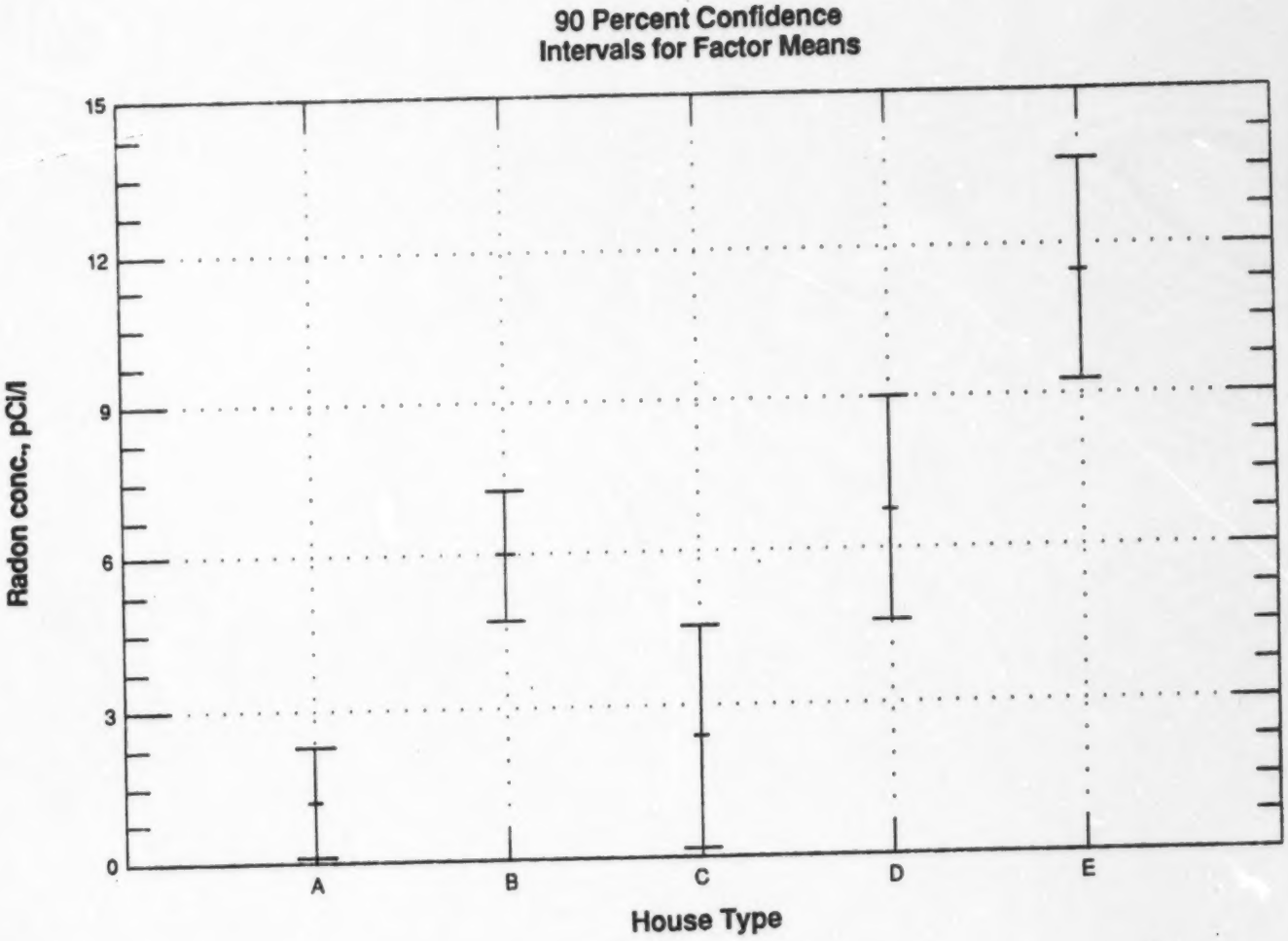

Figure 3. Six-month average radon concentration for each type of house construction, pCi/liter. (see Reference 1 for definitions of construction types)

TABLE 5. TABLE OF MEAN RADON CONCENTRATIONS BY HOUSE TYPE

Level	Count	Average	Stnd. Error (internal)	Stnd. Error (pooled s)	90 Percent Confidence for mean	
house type						
A	48	4.204167	.4326231	.4409986	3.472108	4.936226
B	36	7.402778	.6160999	.5092213	6.557469	8.248087
C	12	4.991667	.3639968	.8819972	3.527548	6.455785
D	12	7.933333	1.2530166	.8819972	6.469215	9.397452
E	12	11.033333	1.0199772	.8819972	9.569215	12.497452
level						
1 downstair	60	6.931667	.5662369	.3944411	6.276893	7.586440
2 upstairs	60	5.665000	.4302990	.3944411	5.010226	6.319774
period						
1 Jan-Apr	60	5.553333	.3814296	.3944411	4.898560	6.208107
2 Apr-July	60	7.043333	.5958821	.3944411	6.388560	7.698107
type by level						
A 1	24	4.554167	.7398095	.6236662	3.518879	5.589455
A 2	24	3.854167	.4549239	.6236662	2.818879	4.889455
B 1	18	7.838889	.9631491	.7201477	6.643441	9.034336
B 2	18	6.966667	.7829056	.7201477	5.771219	8.162114
C 1	6	5.116667	.4308261	1.2473324	3.046091	7.187242
C 2	6	4.866667	.6253888	1.2473324	2.796091	6.937242
D 1	6	11.783333	.8859709	1.2473324	9.712758	13.853909
D 2	6	4.083333	.4407695	1.2473324	2.012758	6.153909
E 1	6	10.683333	2.0329644	1.2473324	8.612758	12.753909
E 2	6	11.383333	.6289762	1.2473324	9.312758	13.453909
type by period						
A 1	24	3.716667	.4672098	.6236662	2.681379	4.751955
A 2	24	4.691667	.7252415	.6236662	3.656379	5.726955
B 1	18	6.033333	.4452362	.7201477	4.837886	7.228781
B 2	18	8.772222	1.0696284	.7201477	7.576775	9.967670
C 1	6	4.833333	.5129436	1.2473324	2.762758	6.903909
C 2	6	5.150000	.5566267	1.2473324	3.079424	7.220576
D 1	6	7.816667	1.4914013	1.2473324	5.746091	9.887242
D 2	6	8.050000	2.1629840	1.2473324	5.979424	10.120576
E 1	6	9.916667	.9321719	1.2473324	7.846091	11.987242
E 2	6	12.150000	1.7916008	1.2473324	10.079424	14.220576
level by period						
1 1	30	5.980000	.5678838	.5578240	5.054010	6.905990
1 2	30	7.883333	.9589875	.5578240	6.957344	8.809323
2 1	30	5.126667	.5068935	.5578240	4.200677	6.052656
2 2	30	6.203333	.6902687	.5578240	5.277344	7.129323
Total	120	6.298333	.2789120	.2789120	5.835339	6.761328

TABLE 6. TABLE OF MEAN RADON CONCENTRATION BY INDIVIDUAL HOUSE

Level	Count	Average	Stnd. Error (internal)	Stnd. Error (pooled s)	90 Percent Confidence for mean	
house						
1	12	3.258333	.1916667	.4727958	2.472300	4.044367
2	12	8.858333	1.5040581	.4727958	8.072300	9.644367
3	12	4.991667	.3639968	.4727958	4.205633	5.777700
4	12	3.241667	.1648959	.4727958	2.455633	4.027700
5	12	8.541667	.8321621	.4727958	7.755633	9.327700
6	12	8.550000	.4129531	.4727958	7.763966	9.336034
7	12	11.033333	1.0199772	.4727958	10.247300	11.819367
8	12	1.775000	.1732597	.4727958	.988966	2.561034
9	12	4.800000	.5122736	.4727958	4.013966	5.586034
10	12	7.933333	1.2530166	.4727958	7.147300	8.719367
level						
1	60	6.931667	.5662369	.2114407	6.580142	7.283192
2	60	5.665000	.4302990	.2114407	5.313475	6.016525
period						
1	60	5.553333	.3814296	.2114407	5.201808	5.904858
2	60	7.043333	.5958821	.2114407	6.691808	7.394858
house by level						
1 1	6	3.133333	.3116266	.6686343	2.021714	4.244953
1 2	6	3.383333	.2414079	.6686343	2.271714	4.494953
2 1	6	10.300000	2.3653048	.6686343	9.188381	11.411619
2 2	6	7.416667	1.8781936	.6686343	6.305047	8.528286
3 1	6	5.116667	.4308261	.6686343	4.005047	6.228286
3 2	6	4.866667	.6253888	.6686343	3.755047	5.978286
4 1	6	3.333333	.2812670	.6686343	2.221714	4.444953
4 2	6	3.150000	.1927866	.6686343	2.038381	4.261619
5 1	6	10.066667	1.1884631	.6686343	8.955047	11.178286
5 2	6	7.016667	.8392126	.6686343	5.905047	8.128286
6 1	6	8.316667	.6467440	.6686343	7.205047	9.428286
6 2	6	8.783333	.5570258	.6686343	7.671714	9.894953
7 1	6	10.683333	2.0329644	.6686343	9.571714	11.794953
7 2	6	11.383333	.6289762	.6686343	10.271714	12.494953
8 1	6	1.683333	.2329759	.6686343	.571714	2.794953
8 2	6	1.866667	.2728451	.6686343	.755047	2.978286
9 1	6	4.900000	.6816646	.6686343	3.788381	6.011619
9 2	6	4.700000	.8282512	.6686343	3.588381	5.811619
10 1	6	11.783333	.8859709	.6686343	10.671714	12.894953
10 2	6	4.083333	.4407695	.6686343	2.971714	5.194953
house by period						
1 1	6	2.766667	.1201850	.6686343	1.655047	3.878286
1 2	6	3.750000	.2247221	.6686343	2.638381	4.861619
2 1	6	4.150000	.4333974	.6686343	3.038381	5.261619
2 2	6	13.566667	.9478631	.6686343	12.455047	14.678286
3 1	6	4.833333	.5129436	.6686343	3.721714	5.944953
3 2	6	5.150000	.5566267	.6686343	4.038381	6.261619
4 1	6	3.516667	.2508873	.6686343	2.405047	4.628286
4 2	6	2.966667	.1626175	.6686343	1.855047	4.078286
5 1	6	6.983333	.8125748	.6686343	5.871714	8.094953
5 2	6	10.100000	1.1896778	.6686343	8.988381	11.211619
6 1	6	7.783333	.4853979	.6686343	6.671714	8.894953
6 2	6	9.316667	.5287827	.6686343	8.205047	10.428286
7 1	6	9.916667	.9321719	.6686343	8.805047	11.028286
7 2	6	12.150000	1.7916008	.6686343	11.038381	13.261619
8 1	6	1.600000	.2449490	.6686343	.488381	2.711619
8 2	6	1.950000	.2446085	.6686343	.838381	3.061619

(continued)

TABLE 6 (continued)

Level		Count	Average	Stnd. Error (internal)	Stnd. Error (pooled s)	90 Percent Confidence for mean	
9	1	6	6.166667	.5226003	.6686343	5.055047	7.278286
9	2	6	3.433333	.3666667	.6686343	2.321714	4.544953
10	1	6	7.816667	1.4914013	.6686343	6.705047	8.928286
10	2	6	8.050000	2.1629840	.6686343	6.938381	9.161619
level by period							
1	1	30	5.980000	.5678838	.2990223	5.482869	6.477131
1	2	30	7.883333	.9589875	.2990223	7.386202	8.380465
2	1	30	5.126667	.5068935	.2990223	4.629535	5.623798
2	2	30	6.203333	.6902687	.2990223	5.706202	6.700465
Total		120	6.298333	.1495112	.1495112	6.049768	6.546899

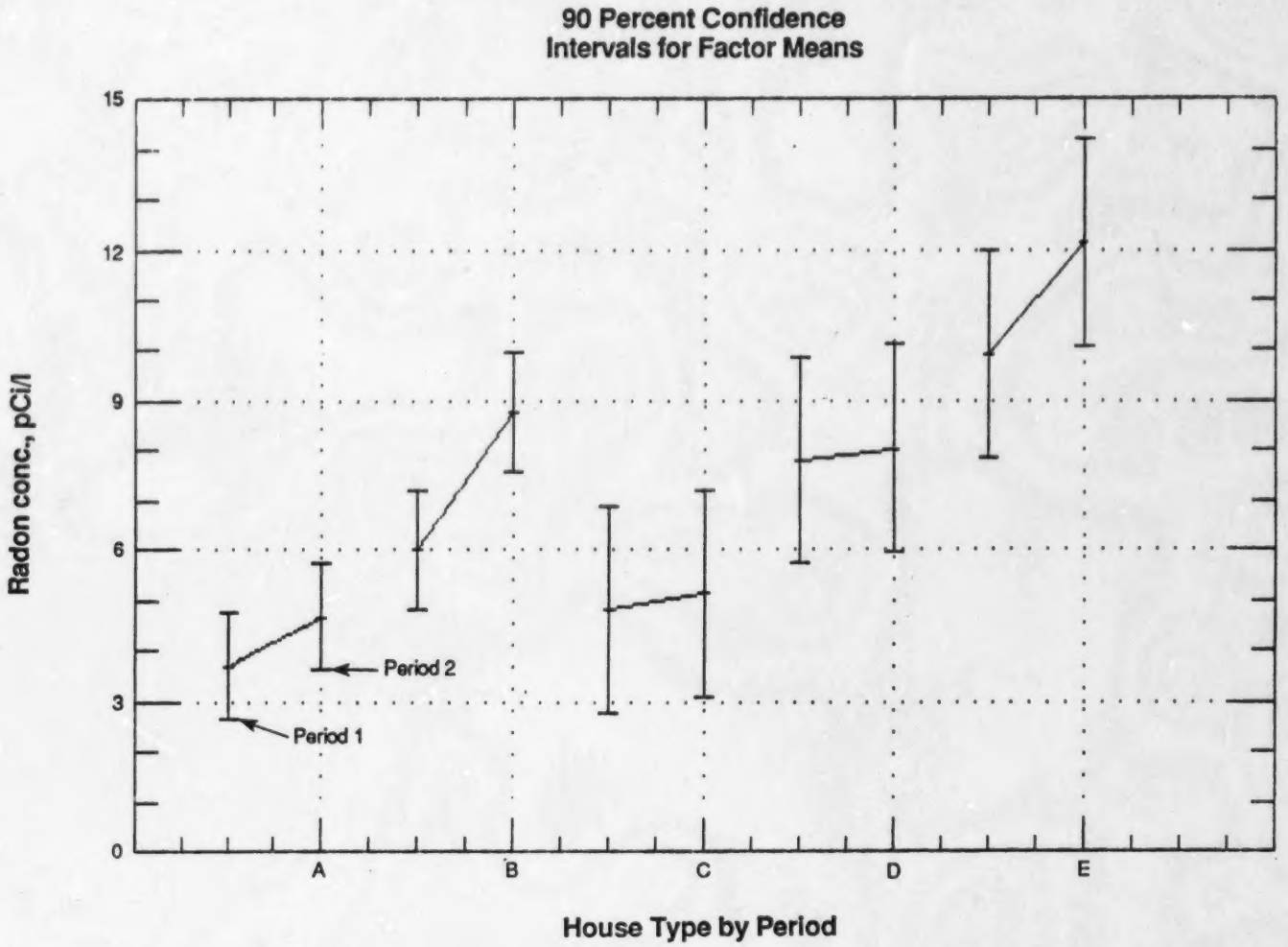

Figure 4. Comparison of radon concentrations for each type of house construction between sampling periods, pCi/liter.

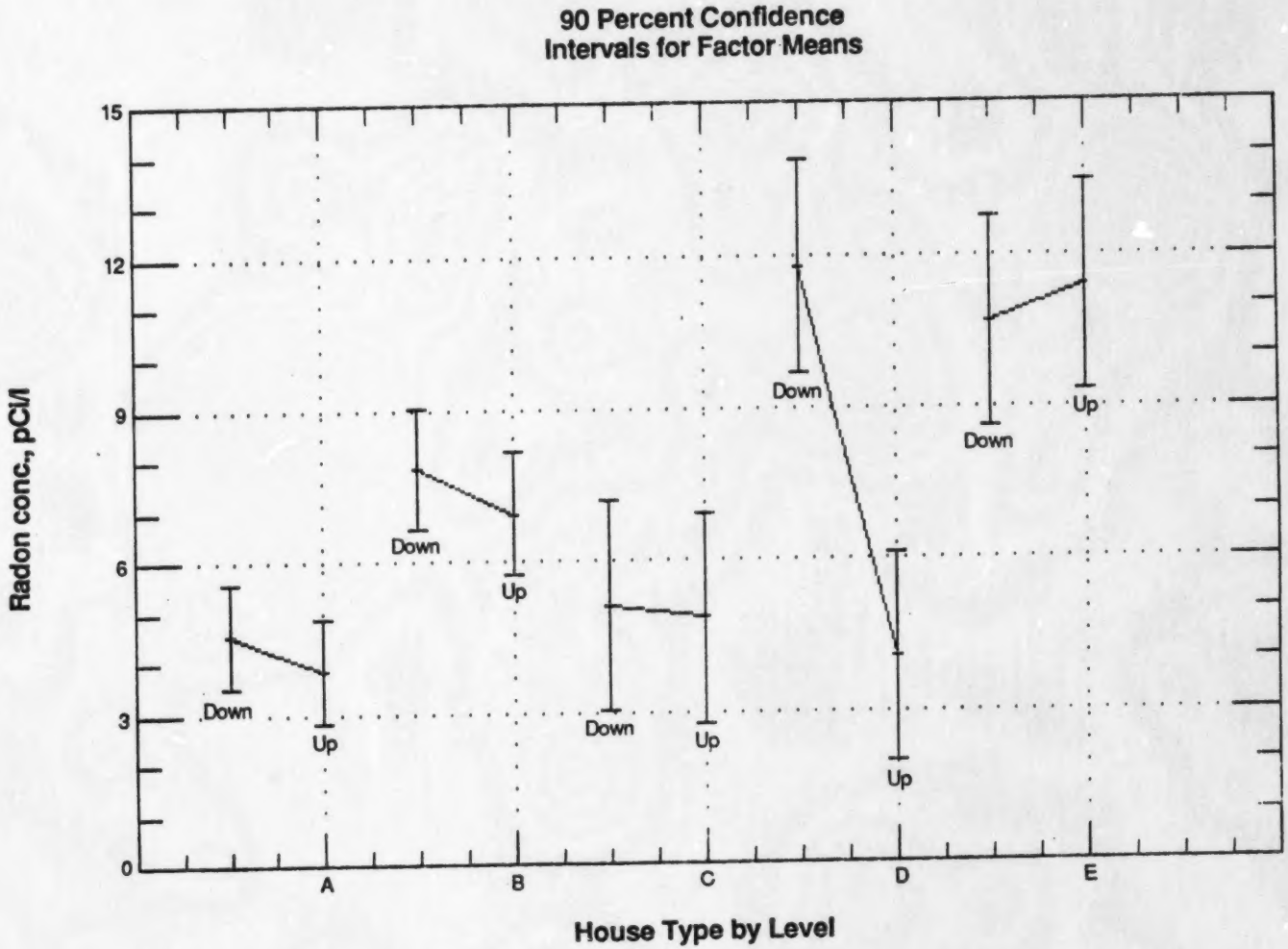

Figure 5. Comparison of six-month average radon concentrations between floor levels, pCi/liter.

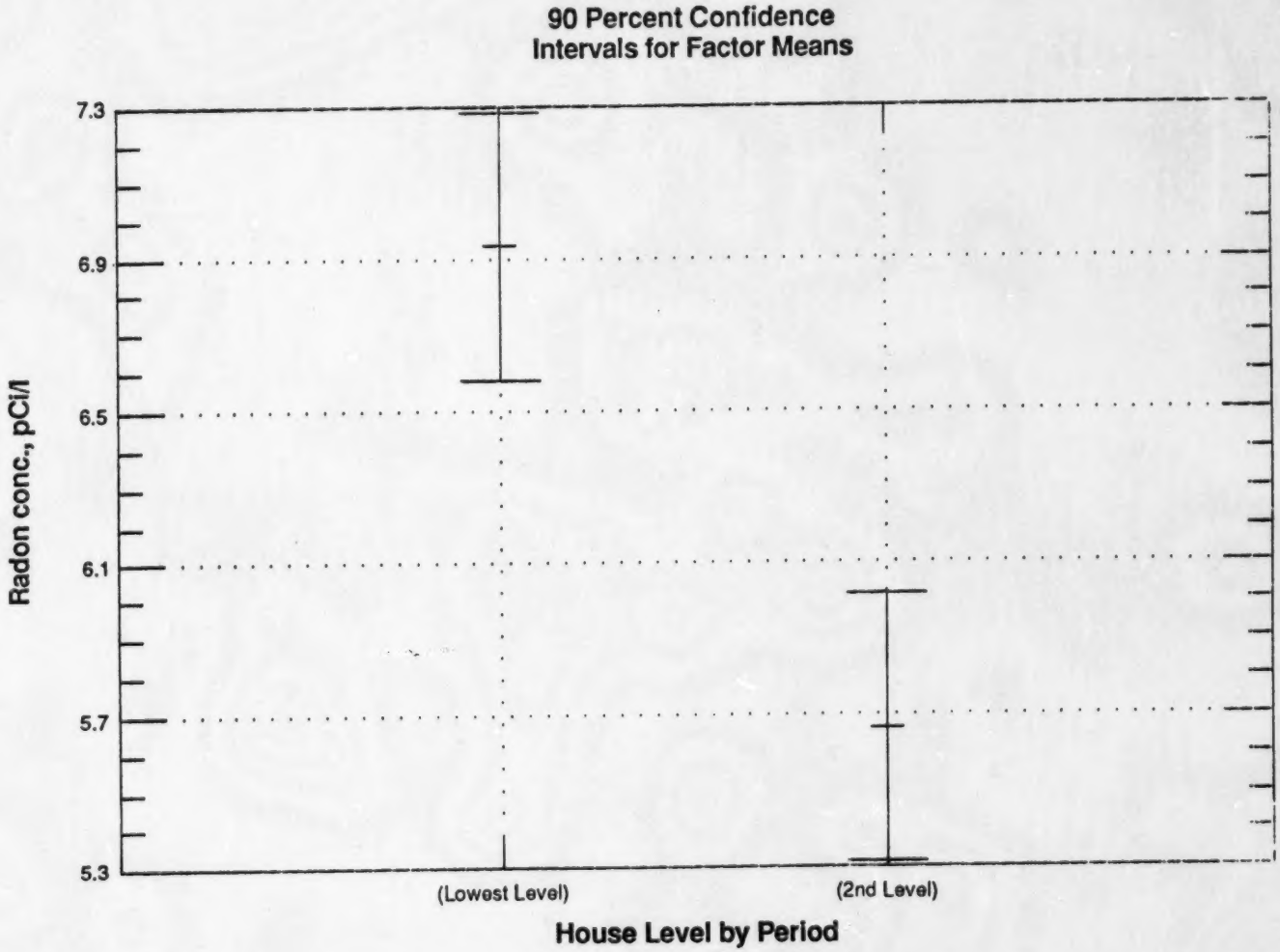

Figure 6. Six-month average radon concentrations sorted by level of the house, pCi/liter.

As an additional analysis of the data collected during the two sampling periods, a frequency histogram of the values was plotted to determine the distribution function best describing the data. Figure 7 presents the histogram of the 120 ATD data values generated during the first and second sampling period and the lognormal distribution curve fitted to the data. As suggested by this figure, and as confirmed by the summary statistics generated by the Chi-square test (see Table 7), the data could reasonably be described by a lognormal distribution curve.

Although a direct comparison of pre- and post-mitigation concentrations yield only partially valid conclusions (because the measurements were made during different seasons and house conditions), the data in Table 4 indicate that substantial reductions have been achieved in many of the study houses.

EFFECT OF ADDITIONAL MITIGATION (HOUSES C7 AND C10)

The results of the special study are also provided in Table 3. These results are based on samples collected shortly after the additional remediation was completed in the two houses included in the special study. The special study results show an improvement in the radon levels in house C10-D, but little or no improvement in the levels measured in house C7-E. Because of the short-term nature of the charcoal canister measurements, however, the effect of the additional remediation in these two houses cannot be fully assessed until after an additional three-month ATD average concentration is obtained.

QUALITY CONTROL EVALUATION REPORT

The relative standard deviation (RSD) of the triplicate ATD samples was calculated to estimate the precision of the monitoring method. Each ATD was

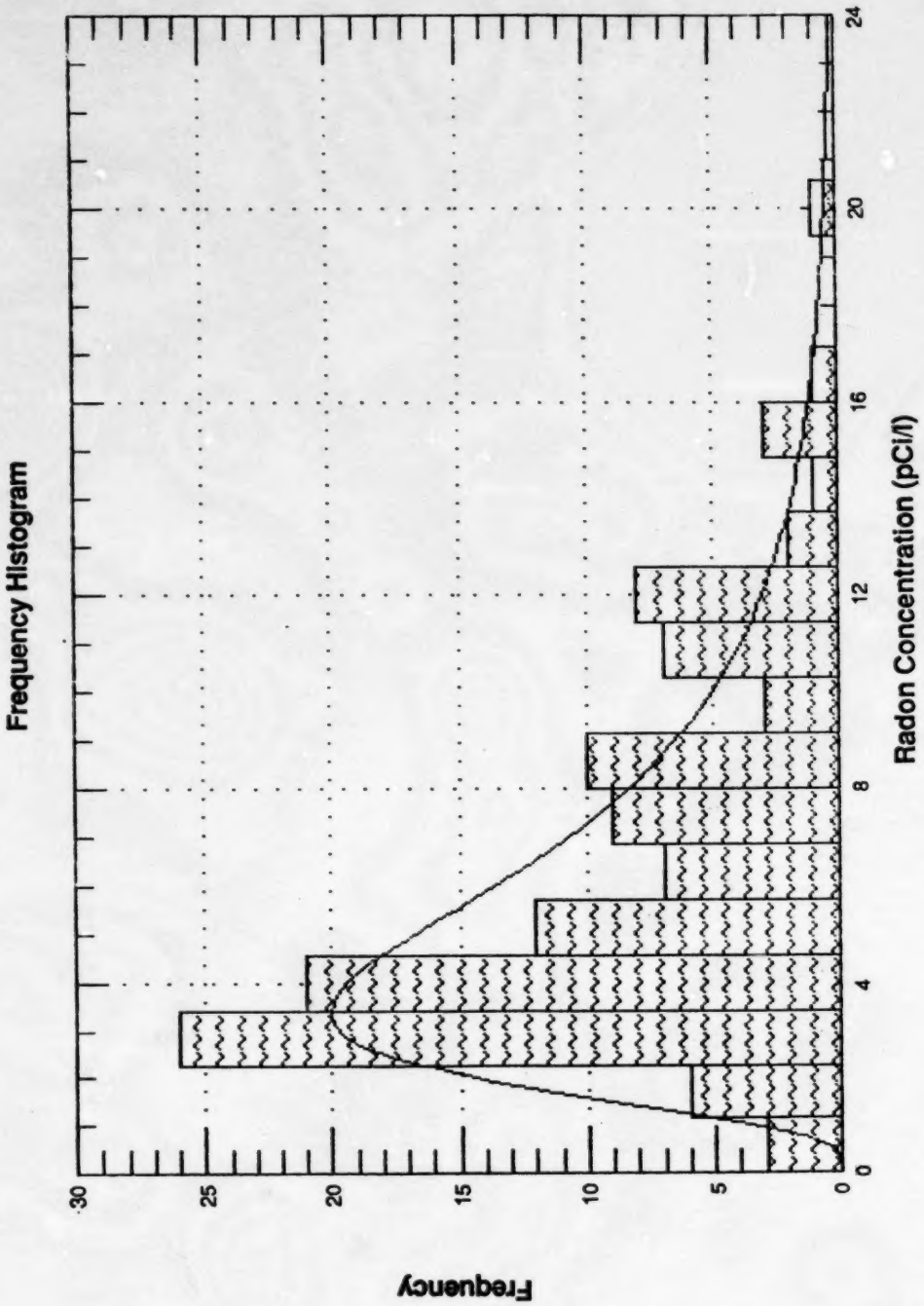

Figure 7. Lognormal frequency distribution of radon concentration data, pCi/liter.

TABLE 7. CHI SQUARE ANALYSIS OF LOGNORMAL FREQUENCY DISTRIBUTION

Chisquare Test

	Lower Limit	Upper Limit	Observed Frequency	Expected Frequency	Chisquare
	at or below	2.29	9	13	1.0553
	2.29	3.43	26	19	2.4924
	3.43	4.57	21	19	.1493
	4.57	5.71	12	16	1.1362
	5.71	6.86	7	13	2.6160
	6.86	8.00	9	10	.0509
	8.00	9.14	10	7	1.0266
	9.14	10.29	3	5	1.0844
	10.29	12.57	15	7	8.7878
above	12.57		8	10	.5372

Chisquare = 18.9361 with 7 d.f. Sig. level = 8.38997E-3

counted in triplicate by the analysis laboratory, and with the exception of the blanks, each result was reported to have a standard deviation percentage of less than 20 percent (See appendix A). The RSD was also calculated for each result based on the triplicate samples. Eight sets of samples were found to have an RSD greater than 20 percent. Five of the eight sets produced average radon concentrations less than 4 pCi/liter; the high RSD can be explained by the difficulties encountered in counting at low levels. The three remaining sets all had individual results greater then 4 pCi/liter, which indicates that the levels are probably still above the target level. Two of these three sets had an average radon concentration greater than 11 pCi/liter. In general, however, there is no firm reason to doubt the validity of the results for any of the samples collected.

REFERENCES

1. U.S. Environmental Protection Agency, "Development and Demonstration of Indoor Radon Reduction Measures for 10 Homes in Clinton, New Jersey," EPA-600/8-87-027 (NTIS PB87-215356), July 1987.

2. U.S. Environmental Protection Agency, Interim Indoor Radon and Radon Decay Product Measurement Protocols, EPA-520/1-86-04 (NTIS PB86-215258), April 1986.

APPENDIX A

DATA REPORTS

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

APR 17, 1987

PEI ASSOCIATES
ATTN MIKE ARGZARENA
11499 CHESTER ROAD
CINCINNATI OH 45246

RE: ACCOUNT NO 400466

DEAR CLIENT:

ENCLOSED ARE THE TRACK ETCH RADON RESULTS FOR YOUR RECENT RADON MONITORING PROGRAM. A SUMMARY SHEET PROVIDING GENERAL INFORMATION ABOUT YOUR RESULTS IS PROVIDED. FOLLOWING THE SUMMARY IS A LISTING OF YOUR RESULTS GIVEN IN AVERAGE PICOCURIES PER LITER OF RN-222 (PCI/L) OVER THE EXPOSURE PERIOD USED. THE RESULTS ARE RANKED BY MONITOR NUMBER.

IF YOUR RADON LEVEL IS:

1. LESS THAN 4.0 PCI/L, IT IS BELOW ANY RECOMMENDED GUIDELINE.

2. BETWEEN 4.0 AND 8.0 PCI/L, IT EXCEEDS THE GUIDELINES RECOMMENDED BY THE EPA AND OTHER AGENCIES.

3. GREATER THAN 8.0 PCI/L, IT EXCEEDS THE NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS GUIDELINES.

TERRADEX DOES NOT ACCEPT RESPONSIBILITY FOR FINANCIAL OR HEALTH CONSEQUENCES OF SUBSEQUENT ACTION TAKEN BY THE CLIENT OR ITS CONSULTANTS BASED ON THESE RESULTS, NOR ARE WE RESPONSIBLE FOR THE RESULTS OF IMPROPER PLACEMENT OF DETECTORS.

IT IS A PLEASURE TO BE OF SERVICE TO YOU, AND WE LOOK FORWARD TO SERVING YOU AGAIN IN THE NEAR FUTURE. PLEASE LET US KNOW IF YOU HAVE ANY COMMENTS ABOUT THIS REPORT.

SINCERELY,

TERRADEX
A SUBSIDIARY OF TECH/OPS, INC.

ENCLOSURE

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

TERRADEX CORPORATION
A SUBSIDIARY OF TECH/OPS, INC.

TRACK ETCH RADON RESULTS

SUMMARY FOR ACCOUNT: 400466

PROGRAM NAME:	PEI ASSOCIATES
PROGRAM DATE:	APR 17, 1987
MINIMUM EXPOSURE TIME (DAYS):	88
MAXIMUM EXPOSURE TIME (DAYS):	88
MINIMUM RADON VALUE (PCI/L):	5.1
MAXIMUM RADON VALUE (PCI/L):	10.2
TOTAL MONITORS READ:	6
NO. OF TYPE SF MONITORS:	6

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

400466 PEI ASSOCIATES

APR 17, 1987

MONITOR NUMBER	RADON EXP. RATE (PCI/LITER)	STD. DEV. PER.	MATR TYPE	FIELD NOTES AND DATA
/ 465029	5.1	17.1	SF	
✓ 465030	5.4	16.7	SF	
✓ 465031	10.2	17.1	SF	
✓ 465032	8.4	16.9	SF	
✓ 465041	5.8	16.0	SF	
/ 465046	7.0	14.6	SF	

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

MAY 4, 1987

PEI ASSOCIATES INC
JOE CARVITTI
11499 CHESTER RD
CINCINNATI OH 45246

RE: ACCOUNT NO 400468

DEAR CLIENT:

ENCLOSED ARE THE TRACK ETCH RADON RESULTS FOR YOUR RECENT RADON MONITORING PROGRAM. A SUMMARY SHEET PROVIDING GENERAL INFORMATION ABOUT YOUR RESULTS IS PROVIDED. FOLLOWING THE SUMMARY IS A LISTING OF YOUR RESULTS GIVEN IN AVERAGE PICOCURIES PER LITER OF RN-222 (PCI/L) OVER THE EXPOSURE PERIOD USED. THE RESULTS ARE RANKED BY MONITOR NUMBER.

IF YOUR RADON LEVEL IS:

1. LESS THAN 4.0 PCI/L, IT IS BELOW ANY RECOMMENDED GUIDELINE.

2. BETWEEN 4.0 AND 8.0 PCI/L, IT EXCEEDS THE GUIDELINES RECOMMENDED BY THE EPA AND OTHER AGENCIES.

3. GREATER THAN 8.0 PCI/L, IT EXCEEDS THE NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS GUIDELINES.

TERRADEX DOES NOT ACCEPT RESPONSIBILITY FOR FINANCIAL OR HEALTH CONSEQUENCES OF SUBSEQUENT ACTION TAKEN BY THE CLIENT OR ITS CONSULTANTS BASED ON THESE RESULTS, NOR ARE WE RESPONSIBLE FOR THE RESULTS OF IMPROPER PLACEMENT OF DETECTORS.

IT IS A PLEASURE TO BE OF SERVICE TO YOU, AND WE LOOK FORWARD TO SERVING YOU AGAIN IN THE NEAR FUTURE. PLEASE LET US KNOW IF YOU HAVE ANY COMMENTS ABOUT THIS REPORT.

SINCERELY,

TERRADEX
A SUBSIDIARY OF TECH/OPS, INC.

ENCLOSURE

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

TRACK ETCH RADON RESULTS

SUMMARY FOR ACCOUNT: 400468

PROGRAM NAME:	PEI ASSOCIATES
PROGRAM DATE:	MAY 4, 1987
MINIMUM EXPOSURE TIME (DAYS):	101
MAXIMUM EXPOSURE TIME (DAYS):	102
MINIMUM RADON VALUE (PCI/L):	1.0
MAXIMUM RADON VALUE (PCI/L):	12.4
TOTAL MONITORS READ:	54
NO. OF TYPE SF MONITORS:	54

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

400468 PEI ASSOCIATES

MAY 4, 1987

MONITOR NUMBER	RADON EXP. RATE (PCI/LITER)	STD. DEV. PER.	MNTR TYPE	FIELD NOTES AND DATA
465001	7.6	13.1	SF	
465002	6.8	19.6	SF	
465003	6.8	19.6	SF	
465004	6.7	14.0	SF	
465005	8.9	17.1	SF	
465006	2.5	18.3	SF	
465007	2.1	20.0	SF	
465008	4.4	17.1	SF	
465010	3.1	16.7	SF	
465011	2.6	18.0	SF	
465012	3.9	18.3	SF	
465013	4.5	16.9	SF	
465014	3.3	19.6	SF	
465015	3.9	18.3	SF	
465016	2.6	18.0	SF	
465017	6.3	14.4	SF	
465018	12.1	14.7	SF	
465019	7.9	18.3	SF	
465020	4.5	16.9	SF	
465021	6.5	14.1	SF	
465022	6.6	17.4	SF	

TERRADEX

TERRADEX CORPORATION

3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

400468 PEI ASSOCIATES MAY 4, 1967

MONITOR NUMBER	RADON EXP. RATE (PCI/LITER)	STD. DEV. PER.	MNTR TYPE	FIELD NOTES AND DATA
465023	12.4	14.6	SF	
465024	3.0	16.9	SF	
465025	2.8	17.4	SF	
465026	4.1	17.7	SF	
465027	3.3	19.6	SF	
465028	4.3	17.4	SF	
465029	7.1	19.2	SF	
465033	9.4	16.7	SF	
465034	1.5	20.4	SF	
465035	8.1	16.0	SF	
465036	1.0	25.0	SF	
465037	1.5	20.4	SF	
465038	7.3	18.9	SF	
465039	1.0	25.0	SF	
465040	3.3	19.6	SF	
465042	4.1	17.7	SF	
465043	5.3	15.6	SF	
465044	4.9	16.2	SF	
465045	4.9	16.2	SF	
465047	6.5	20.0	SF	
465048	4.9	16.2	SF	

TERRADEX

TERRADEX CORPORATION

3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

400468 PEI ASSOCIATES MAY 4, 1987

MONITOR NUMBER	RADON EXP. RATE (PCI/LITER)	STD. DEV. PER.	MNTR TYPE	FIELD NOTES AND DATA
465049	12.4	14.6	SF	
465050	5.5	15.4	SF	
465051	4.5	16.9	SF	
465052	8.9	17.1	SF	
465053	11.8	14.9	SF	
465054	11.3	15.2	SF	
465055	2.4	18.9	SF	
465056	2.6	18.0	SF	
465057	2.6	18.0	SF	
465058	4.9	16.2	SF	
465059	4.9	16.2	SF	
465060	3.2	20.0	SF	

OFFICE OF RADIATION PROGRAMS
Eastern Environmental Radiation Facility
1890 Federal Drive, Montgomery, Al 36109

May 5, 1987

Mr. Joe Carvitti
PEI Associates
11499 Chester Road
Cincinnati, OH 45246

Dear Mr. Carvitti:

Enclosed are the results from the analysis of charcoal canisters deployed by your organization recently. The report contains data from all canisters received April 20 through May 1, 1987.

If you have any questions about the data, please call me at (205) 272-3402.

Sincerely,

Sam T. Windham

Sam T. Windham, Chief
Environmental Studies Branch

Enclosure

cc: Sheldon Meyers, OD/ORP (ANR-458), w/o enclosure
Carol J. Jordan, (ANR-459), w/o enclosure
Richard J. Guimond, RAP/ORP (ANR-460), w/o enclosure
Dan Egan, CSD/ORP (ANR-460), w/enclosure

4-MAY-1987 8:31

House Id	Canister Number	ZIP Code	Geol. Rgn	Type Bldg.	Floor	Room	Doors & Windows	Exposure Period Start Date	Exposure Period Stop Date	Exposure Period Start Time	Exposure Period Stop Time	Activity (pCi/l)	% Error (2 Sigma)
PEINJ00011	32600	08809		1	1	7	CLOSED	4/16/87	4/20/87	1025	1551	4.9	5.1
Comments:DINING ROOM													
PEINJ00012	32530	08809		1	0	4	CLOSED	4/16/87	4/20/87	1040	1554	5.2	4.7
PEINJ00021	32570	08809		1	0	7	CLOSED	4/16/87	4/20/87	1446	1536	2.6	8.2
Comments:DINING ROOM													
PEINJ00022	32611	08809		1	0	7	CLOSED	4/16/87	4/20/87	1450	1538	4.8	7.1
Comments:FINISHED BSMT													
PEINJ00031	32561	08809		1	1	7	CLOSED	4/16/87	4/20/87	1410	1528	10.5	3.9
Comments:DINING ROOM													
PEINJ00032	32580	08809		1	2	1	CLOSED	4/16/87	4/20/87	1423	1532	5.6	4.7
PEINJ00041	32620	08809		1	1	2	CLOSED	4/16/87	4/20/87	1322	1517	5.9	5.9
PEINJ00042	32590	08809		1	0	4	CLOSED	4/16/87	4/20/87	1336	1520	9.1	4.3
PEINJ00051	32531	08809		1	0	4	CLOSED	4/17/87	4/20/87	1045	1610	11.7	2.9
PEINJ00052	32661	08809		1	1	7	CLOSED	4/17/87	4/20/87	1035	1607	10.3	3.7
Comments:DINING ROOM													
PEINJ00061	32560	08809		1	1	7	CLOSED	4/16/87	4/20/87	1718	1621	12.7	3.5
Comments:FAMILY ROOM													
PEINJ00062	32631	08809		1	2	7	CLOSED	4/16/87	4/20/87	1630	1624	10.8	3.1
Comments:DINING ROOM													
PEINJ00081	32581	08809		1	0	7	CLOSED	4/17/87	4/20/87	1008	1644	2.1	8.7
Comments:FINISHED BSMT													
PEINJ00082	32651	08809		1	1	7	CLOSED	4/17/87	4/20/87	0957	1642	2.0	9.4
Comments:DINING ROOM													
PEINJ00091	32520	08809		1	0	7	CLOSED	4/16/87	4/20/87	1648	1636	3.2	8.6
Comments:FINISHED BASEMENT													
PEINJ00092	32641	08809		1	1	7	CLOSED	4/16/87	4/20/87	1645	1632	1.9	10.8
Comments:DINING ROOM													
PEINJ00131	32550	08809		1	1	7	CLOSED	4/16/87	4/20/87	1410	1529	10.6	3.9

TYPE BLDG: 1= SINGLE FAMILY HOME 2= MULTI-FAMILY DWELL. 3= BUSINESS 4= SCHOOL 5= OTHER
FLOOR : 0= BASEMENT 1= 1ST FLOOR 2= 2ND FLOOR OR ABOVE 4= UNFINISHED BASEMENT
ROOM : 1= BEDROOM 2= FAMILY ROOM 3= LIVING ROOM
5= OFFICE 6= CLASSROOM 7= OTHER

House Id		Canister Number	ZIP Code	Geol. Rgn	Type Bldg.	Floor	Room	Doors & Windows	Exposure Period Date Start	Date Stop	Time Start	Time Stop	Activity (pCi/l)	% Error (2 Sigma)
PEINJ00231	✓	32521	08809		1	1	2	CLOSED	4/16/87	4/20/87	1411	1528	< 0.5	

TYPE BLDG: 1= SINGLE FAMILY HOME 2= MULTI-FAMILY DWELL. 3= BUSINESS 4= SCHOOL 5= OTHER
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5= OFFICE 6= CLASSROOM 7= OTHER

OFFICE OF RADIATION PROGRAMS
Eastern Environmental Radiation Facility
1890 Federal Drive, Montgomery, Al 36109

May 19, 1987

Mr. Joe Carvitti
PEI Associates
11499 Chester Road
Cincinnati, OH 45246

Dear Mr. Carvitti:

Enclosed are the results from the analysis of charcoal canisters deployed by your organization recently. The report contains data from all canisters received May 4 through May 15, 1987.

If you have any questions about the data, please call me at (205) 272-3402.

Sincerely,

Sam T. Windham, Chief
Environmental Studies Branch

Enclosure

cc: Sheldon Meyers, OD/ORP (ANR-458), w/o enclosure
Carol J. Jordan, (ANR-459), w/o enclosure
Richard J. Guimond, RAP/ORP (ANR-460), w/o enclosure
Dan Egan, CSD/ORP (ANR-460), w/enclosure

18-MAY-1987 8:32

House Id	Canister Number	ZIP Code	Geol. Rgn	Type Bldg.	Floor	Room	Doors & Windows	Exposure Period Date Start	Date Stop	Time Start	Time Stop	Activity (pCi/l)	% Error (2 Sigma)
PEINJ00072	32551	08809		1	1	3	CLOSED	5/ 8/87	5/11/87	1619	1850	14.7	2.5
PEINJ00101	32591	08809		1	0	4	CLOSED	5/ 8/87	5/11/87	1611	1905	23.2	1.9
PEINJ00102	32540	08809		1	1	7	CLOSED	5/ 8/87	5/11/87	1607	1902	3.8	5.7
Comments:DINING ROOM													
PEINJ00171	32621	08809		1	1	2	CLOSED	5/ 8/87	5/11/87	1621	1853	13.8	2.6
PEINJ00271	32571	08809		1	1	2	CLOSED	5/ 8/87	5/11/87	1630	1855	< 0.5	
PEINJ00371	32601	08809		1	1	2	CLOSED	5/ 8/87	5/11/87	1624	1853	13.6	2.6

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TYPE BLDG: 1= SINGLE FAMILY HOME 2= MULTI-FAMILY DWELL. 3= BUSINESS 4= SCHOOL 5= OTHER
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5= OFFICE 6= CLASSROOM 7= OTHER

TERRADEX

TERRADEX CORPORATION

3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

JUL 29, 1987

RECEIVED
AUG - 4 1987
PEI ASSOCIATES, INC.
By_____

PEI ASSOCIATES INC
JOE CARVITTI
11499 CHESTER RD
CINCINNATI OH 45246

RE: ACCOUNT NO 400468

DEAR CLIENT:

ENCLOSED ARE THE TRACK ETCH RADON RESULTS FOR YOUR RECENT RADON MONITORING PROGRAM. A SUMMARY SHEET PROVIDING GENERAL INFORMATION ABOUT YOUR RESULTS IS PROVIDED. FOLLOWING THE SUMMARY IS A LISTING OF YOUR RESULTS GIVEN IN AVERAGE PICOCURIES PER LITER OF RN-222 (PCI/L) OVER THE EXPOSURE PERIOD USED. THE RESULTS ARE RANKED BY MONITOR NUMBER.

IF YOUR RADON LEVEL IS:

1. LESS THAN 4.0 PCI/L, IT IS BELOW ANY RECOMMENDED GUIDELINE.

2. BETWEEN 4.0 AND 8.0 PCI/L, IT EXCEEDS THE GUIDELINES RECOMMENDED BY THE EPA AND OTHER AGENCIES.

3. GREATER THAN 8.0 PCI/L, IT EXCEEDS THE NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS GUIDELINES.

TERRADEX DOES NOT ACCEPT RESPONSIBILITY FOR FINANCIAL OR HEALTH CONSEQUENCES OF SUBSEQUENT ACTION TAKEN BY THE CLIENT OR ITS CONSULTANTS BASED ON THESE RESULTS, NOR ARE WE RESPONSIBLE FOR THE RESULTS OF IMPROPER PLACEMENT OF DETECTORS.

IT IS A PLEASURE TO BE OF SERVICE TO YOU, AND WE LOOK FORWARD TO SERVING YOU AGAIN IN THE NEAR FUTURE. PLEASE LET US KNOW IF YOU HAVE ANY COMMENTS ABOUT THIS REPORT.

SINCERELY,

TERRADEX
A SUBSIDIARY OF TECH/OPS, INC.

ENCLOSURE

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

TRACK ETCH RADON RESULTS

SUMMARY FOR ACCOUNT: 400468

PROGRAM NAME:	PEI ASSOCIATES
PROGRAM DATE:	JUL 29, 1987
MINIMUM EXPOSURE TIME (DAYS):	94
MAXIMUM EXPOSURE TIME (DAYS):	95
MINIMUM RADON VALUE (PCI/L):	1.8
MAXIMUM RADON VALUE (PCI/L):	20.2
TOTAL MONITORS READ:	60
NO. OF TYPE SF MONITORS:	60

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(312) 755-7911

400460 PEI ASSOCIATES JUL 29, 1987

MONITOR NUMBER	RADON EXP. RATE (PCI/LITER)	STD. DEV. PER.	MNTR TYPE	FIELD NOTES AND DATA
474801	7.8 ✓	18.9	SF	
474802	8.9 ✓	17.7	SF	
474803	0.0		SF	BLANK
474805	11.7 ✓	15.4	SF	
474806	1.1 ✓	24.3	SF	
474807	2.9 ✓	17.7	SF	
474808	5.0 ✓	16.7	SF	
474809	2.0 ✓	18.6	SF	
474810	14.6 ✓	13.9	SF	
474811	2.9 ✓	17.7	SF	
474812	3.5 ✓	16.2	SF	
474813	3.8 ✓	18.9	SF	
474814	2.5 ✓	18.9	SF	
474815	2.6 ✓	18.6	SF	
474816	0.3	40.8	SF	BLANK
474817	0.1	50.0	SF	BLANK
474818	0.5	35.4	SF	BLANK
474819	0.0		SF	BLANK
474820	12.0 ✓	15.2	SF	
474821	2.7 ✓	18.3	SF	
474822	3.6 ✓	19.6	SF	

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

400466 PEI ASSOCIATES JUL 29, 1987

MONITOR NUMBER	RADON EXP. RATE (PCI/LITER)	STD. DEV. PER.	MNTR TYPE	FIELD NOTES AND DATA
474823	2.9 ✓	17.7	SF	
474824	3.0 ✓	17.4	SF	
474825	2.6 ✓	18.6	SF	
474826	4.4 ✓	17.7	SF	
474827	5.4 ✓	16.0	SF	
474828	15.1 ✓	13.6	SF	
474829	10.9 ✓	16.0	SF	
474830	8.6 ✓	18.0	SF	
474831	7.9 ✓	13.2	SF	
474832	1.6 ✓	20.4	SF	
474833	15.0 ✓	13.7	SF	
474834	11.6 ✓	15.6	SF	
474835	2.4 ✓	19.6	SF	
474836	10.9 ✓	16.0	SF	
474837	16.5 ✓	13.0	SF	
474838	15.1 ✓	13.6	SF	
474839	4.3 ✓	18.0	SF	
474840	4.7 ✓	17.1	SF	
474841	7.8 ✓	18.9	SF	
474842	4.3 ✓	18.0	SF	
474843	12.8 ✓	14.9	SF	

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

[illegible] PCI ASSOCIATES JUL 29, 1987

MONITOR NUMBER	RADON EXP. RATE (PCI/LITER)	STD. DEV. PER.	MNTR TYPE	FIELD NOTES AND DATA
474844	10.6 ✓	16.2	SF	
474845	9.8 ✓	16.9	SF	
474846	[illegible]		SF	BLANK
474847	[illegible] ✓	16.0	SF	
474848	6.4 ✓	18.3	SF	
474849	8.2 ✓	18.6	SF	
474850	7.[illegible] ✓	20.[illegible]	SF	
477611	11.2 ✓	15.8	SF	
477612	20.2 ✓	11.6	SF	
477613	4.7 ✓	18.3	SF	
477638	1.8 ✓	19.2	SF	
477639	8.1 ✓	18.6	SF	
477640	4.4 ✓	17.7	SF	
477641	10.4 ✓	16.4	SF	
477642	11.2 ✓	15.8	SF	
477645	11.7 ✓	15.4	SF	
477646	13.1 ✓	14.6	SF	
477647	3.3 ✓	16.7	SF	

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

JUL 31, 1987

PEI ASSOCIATES INC
JOE CARVITTI
11499 CHESTER RD
CINCINNATI OH 45246

RE: ACCOUNT NO 400468

DEAR CLIENT:

ENCLOSED ARE THE TRACK ETCH RADON RESULTS FOR YOUR RECENT RADON MONITORING PROGRAM. A SUMMARY SHEET PROVIDING GENERAL INFORMATION ABOUT YOUR RESULTS IS PROVIDED. FOLLOWING THE SUMMARY IS A LISTING OF YOUR RESULTS GIVEN IN AVERAGE PICOCURIES PER LITER OF RN-222 (PCI/L) OVER THE EXPOSURE PERIOD USED. THE RESULTS ARE RANKED BY MONITOR NUMBER.

IF YOUR RADON LEVEL IS:

1. LESS THAN 4.0 PCI/L, IT IS BELOW ANY RECOMMENDED GUIDELINE.

2. BETWEEN 4.0 AND 8.0 PCI/L, IT EXCEEDS THE GUIDELINES RECOMMENDED BY THE EPA AND OTHER AGENCIES.

3. GREATER THAN 8.0 PCI/L, IT EXCEEDS THE NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS GUIDELINES.

TERRADEX DOES NOT ACCEPT RESPONSIBILITY FOR FINANCIAL OR HEALTH CONSEQUENCES OF SUBSEQUENT ACTION TAKEN BY THE CLIENT OR ITS CONSULTANTS BASED ON THESE RESULTS, NOR ARE WE RESPONSIBLE FOR THE RESULTS OF IMPROPER PLACEMENT OF DETECTORS.

IT IS A PLEASURE TO BE OF SERVICE TO YOU, AND WE LOOK FORWARD TO SERVING YOU AGAIN IN THE NEAR FUTURE. PLEASE LET US KNOW IF YOU HAVE ANY COMMENTS ABOUT THIS REPORT.

SINCERELY,

TERRADEX
A SUBSIDIARY OF TECH/OPS, INC.

ENCLOSURE

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

TRACK ETCH RADON RESULTS

SUMMARY FOR ACCOUNT: 400468

PROGRAM NAME:	PEI ASSOCIATES
PROGRAM DATE:	JUL 31, 1987
MINIMUM EXPOSURE TIME (DAYS):	98
MAXIMUM EXPOSURE TIME (DAYS):	108
MINIMUM RADON VALUE (PCI/L):	2.8
MAXIMUM RADON VALUE (PCI/L):	4.3
TOTAL MONITORS READ:	6
NO. OF TYPE SF MONITORS:	6

TERRADEX CORPORATION
3 Science Road
Glenwood, Illinois 60425-1579
(312) 755-7911

400468 PEI ASSOCIATES JUL 31, 1987

MONITOR NUMBER	RADON EXP. RATE (PCI/LITER)	STD. DEV. PER.	MNTR TYPE	FIELD NOTES AND DATA
474804	2.8 ✓	17.7	SF	
477643	4.1 ✓	18.0	SF	
477644	4.1 ✓	18.0	SF	
477648	3.5 ✓	18.6	SF	
477649	4.3 ✓	17.7	SF	
477650	3.7 ✓	18.9	SF	

OFFICE OF RADIATION PROGRAMS
Eastern Environmental Radiation Facility
1890 Federal Drive, Montgomery, Al 36109

August 11, 1987

RECEIVED
AUG 14 1987
PEI ASSOCIATES, INC.
By

Mr. Joe Carvitti
PEI Associates
11499 Chester Road
Cincinnati, OH 45246

Dear Mr. Carvitti:

Enclosed are the results from the analysis of charcoal canisters deployed by your organization recently. The report contains data from all canisters received July 27 through August 7, 1987.

If you have any questions about the data, please call me at (205) 272-3402.

Sincerely,

Sam T. Windham, Chief
Environmental Studies Branch

Enclosure

cc: Sheldon Meyers, OD/ORP (ANR-458), w/o enclosure
Carol J. Jordan, (ANR-459), w/o enclosure
Richard J. Guimond, RAP/ORP (ANR-460), w/o enclosure
Dan Egan, CSD/ORP (ANR-460), w/enclosure

8-AUG-1987 13:34

House Id	Canister Number	ZIP Code	Geol. Rgn	Type Bldg.	Floor	Room	Doors & Windows	Exposure Period Date Start	Exposure Period Date Stop	Exposure Period Time Start	Exposure Period Time Stop	Activity (pCi/l)	% Error (2 Sigma)
PEINJ00071	32588	08809		1	1	2	CLOSED	7/20/87	7/23/87	1343	1641	12.4	3.5
Comments:AIR CONDITIONER TURNED ON													
PEINJ00072	32578	08809		1	1	7	CLOSED	7/20/87	7/23/87	1337	1640	12.1	3.5
Comments:AIR CONDITIONER ON													
PEINJ00073	32541	08809		1	2	1	CLOSED	7/20/87	7/23/87	1349	1640	10.9	3.6
Comments:AIR CONDITIONER ON													

TYPE BLDG: 1= SINGLE FAMILY HOME 2= MULTI-FAMILY DWELL. 3= BUSINESS 4= SCHOOL 5= OTHER
FLOOR : 0= BASEMENT 1= 1ST FLOOR 2= 2ND FLOOR OR ABOVE 4= UNFINISHED BASEMENT
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5= OFFICE 6= CLASSROOM 7= OTHER

OFFICE OF RADIATION PROGRAMS
Eastern Environmental Radiation Facility
1890 Federal Drive, Montgomery, Al 36109

July 28, 1987

Mr. Joe Carvitti
PEI Associates
11499 Chester Road
Cincinnati, OH 45246

Dear Mr. Carvitti:

Enclosed are the results from the analysis of charcoal canisters deployed by your organization recently. The report contains data from all canisters received July 13 through July 24, 1987.

If you have any questions about the data, please call me at (205) 272-3402.

Sincerely,

Sam T. Windham

Sam T. Windham, Chief
Environmental Studies Branch

Enclosure

cc: Sheldon Meyers, OD/ORP (ANR-458), w/o enclosure
Carol J. Jordan, (ANR-459), w/o enclosure
Richard J. Guimond, RAP/ORP (ANR-460), w/o enclosure
Dan Egan, CSD/ORP (ANR-460), w/enclosure

27-JUL-1987 10:23

House Id	Canister Number	ZIP Code	Geol. Rgn	Type Bldg.	Floor	Room	Doors & Windows	Exposure Period				Activity (pCi/l)	% Error (2 Sigma)
								Date Start	Date Stop	Time Start	Time Stop		
HE TN71110	32599	37656	02	1	1	3		7/17/87	7/19/87	1400	1430	21.2	2.4
Comments:UTILITY RM													
HE TN72108	32619	37604	2	1	1	1	OPEN	7/16/87	7/19/87	1400	2045	< 0.5	
PEINJ00101	32579	08809		1	0	4	CLOSED	7/14/87	7/17/87	0920	1000	< 0.5	
PEINJ00102	32629	08809		1	1	2	OPEN	7/14/87	7/17/87	0915	1015	4.4	7.6
Comments:FAMILY ROOM/ KITCHEN													

TYPE BLDG: 1= SINGLE FAMILY HOME 2= MULTI-FAMILY DWELL. 3= BUSINESS 4= SCHOOL 5= OTHER
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